FORM PTO-1390 (REV 10-94) U S DEPARTMENT OF COMMERCE PATENT AND TRADEMARK OFFICE

TRANSMITTAL LETTER TO THE UNITED STATES DESIGNATED/ELECTED OFFICE (DO/EO/US) CONCERNING A FILING UNDER 35 U.S.C. 371

ATTORNEY'S DOCKET NUMBER: 10178.69USWO

U S APPLICATION NO (If known, see 37 C F R 1 5): TO BE ASSIGNED

INTERNATIONAL APPLICATION NO.	INTERNATIONAL FILING DATE	PRIORITY DATE CLAIMED
PCT/FI97/00318	26 May 1997	27 May 1996 09/194297

TITLE OF INVENTION

METHOD FOR DETERMINING THE POSITION OF A MOBILE STATION

APPLICANT(S) FOR DO/EO/US

PALLONEN, Jorma

Applicant herewith submits to the United States Designated/Elected Office (DO/EO/US) the following items and other information:

1. [X] This is a **FIRST** submission of items concerning a filing under 35 U.S.C. 371.
2. [ ] This is a **SECOND** or **SUBSEQUENT** submission of items concerning a filing under 35 U.S.C. 371.
3. [X] This express request to begin national examination procedures (35 U.S.C. 371(f)) at any time rather than delay examination until the expiration of the applicable time limit set in 35 U.S.C. 371(b) and PCT Articles 22 and 39(l).
4. [X] A proper Demand for International Preliminary Examination was made by the 19th month from the earliest claimed priority date.
5. [X] A copy of the International Application as filed (35 U.S.C. 371(c)(2))
   a. [X] is transmitted herewith (required only if not transmitted by the International Bureau).
   b. [X] has been transmitted by the International Bureau.
   c. [ ] is not required, as the application was filed in the United States Receiving Office (RO/US)
6. [ ] A translation of the International Application into English (35 U.S.C. 371(c)(2)).
7. [ ] Amendments to the claims of the International Application under PCT Article 19 (35 U.S.C. 371(c)(3))
   a. [ ] are transmitted herewith (required only if not transmitted by the International Bureau).
   b. [ ] have been transmitted by the International Bureau.
   c. [ ] have not been made; however, the time limit for making such amendments has NOT expired.
   d. [ ] have not been made and will not be made.
8. [ ] A translation of the amendments to the claims under PCT Article 19 (35 U.S.C. 371(c)(3)).
9. [X] An oath or declaration of the inventor(s) (35 U.S.C. 371 (c)(4)).
10. [ ] A translation of the annexes to the International Preliminary Examination Report under PCT Article 36 (35 U.S.C. 371(c)(5)).

Items 11. to 16. below concern document(s) or information included:

11. [X] An Information Disclosure Statement under 37 CFR 1.97 and 1.98.
12. [ ] An assignment document for recording. A separate cover sheet in compliance with 37 CFR 3.28 and 3.31 is included.
13. [X] A FIRST preliminary amendment.
    [ ] A SECOND of SUBSEQUENT preliminary amendment.
14. [ ] A substitute specification.
15. [ ] A change of power of attorney and/or address letter.
16. [X] Other items or information: Form 1449, copies of 11 references, IB/308

U.S. APPLICATION NO (If known, see 37 C.F.R. 1.5)	INTERNATIONAL APPLICATION NO	ATTORNEY'S DOCKET NUMBER
TO BE ASSIGNED	PCT/FI97/00318	10178.69USWO

17. [X] The following fees are submitted:

BASIC NATIONAL FEE (37 CFR 1.492(a) (1)-(5)):

Search Report has been prepared by the EPO or JPO **$930.00**

International preliminary examination fee paid to USPTO (37 CFR 1.492(a)(1)) **$720.00**

No international preliminary examination fee paid to USPTO (37 CFR 1.482) but international search fee paid to USPTO (37 CFR 1.445(a)(2)) **$790.00**

Neither international preliminary examination fee (37 CFR 1.482) nor international search fee (37 CFR 1.445(a)(3)) paid to USPTO **$1,070.00**

International preliminary examination fee paid to USPTO (37 CFR 1.482) and all claims satisfied provisions of PCT Article 33(2)-(4) **$98.00**

	CALCULATIONS PTO USE ONLY	
ENTER APPROPRIATE BASIC FEE AMOUNT =	**$1070**	
Surcharge of **$130.00** for furnishing the oath or declaration later than [ ] 20 [ ] 30 months from the earliest claimed priority date (37 CFR 1.492(e)).	**$0**	

CLAIMS	NUMBER FILED		NUMBER EXTRA	RATE		
Total claims	8	-20 =	8	X **$22.00**	**$8**	
Independent claims	2	-3 =	0	X **$82.00**	**$0**	
MULTIPLE DEPENDENT CLAIM(S) (if applicable)				+ **$270.00**	**$0**	
TOTAL OF ABOVE CALCULATIONS =					**$1070**	
Reduction by 1/2 for filing by small entity, if applicable. Verified Small Entity Statement must also be filed (Note 37 CFR 1.9, 1.27, 1.28).					**$0**	
SUBTOTAL =					**$1070**	
Processing fee of **$130.00** for furnishing the English translation later than [ ] 20 [ ] 30 months from the earliest claimed priority date (37 CFR 1.492(f).				+	**$0**	
TOTAL NATIONAL FEE =					**$1070**	
Fee for recording the enclosed assignment (37 CFR 1.21(h)). The assignment must be accompanied by an appropriate cover sheet (37 CFR 3.28, 3.31). $40.00 per property				+	**$0**	
TOTAL FEES ENCLOSED =					**$0**	
				Amount to be: refunded	**$**	
				charged	**$**	

a. [X] Check(s) in the amount of $1070 to cover the above fees is enclosed.

b. [ ] Please charge my Deposit Account No. _____ in the amount of $ _____ to cover the above fees. A duplicate copy of this sheet is enclosed.

c. [X] The Commissioner is hereby authorized to charge any additional fees which may be required, or credit any overpayment to Deposit Account No. 13-2725.

NOTE: Where an appropriate time limit under 37 CFR 1.494 or 1.495 has not been met, a petition to revive (37 CFR 1.137(a) or (b)) must be filed and granted to restore the application to pending status.

SEND ALL CORRESPONDENCE TO
Michael B. Lasky
MERCHANT & GOULD
3100 Norwest Center
90 South Seventh Street
Minneapolis, MN 55403

SIGNATURE

Michael B. Lasky
NAME

29,555
REGISTRATION NUMBER

09/194297

IN THE UNITED STATES PATENT AND TRADEMARK OFFICE

300 Rec'd PCT/PTO 23 NOV 1998

Applicant: PALLONEN, Jorma

Docket: 10178.69USWO

Title: METHOD FOR DETERMINING THE POSITION OF A MOBILE STATION

CERTIFICATE UNDER 37 CFR 1 10
'Express Mail' mailing label number. EM402708478US
Date of Deposit 23 November 1998
I hereby certify that this paper or fee is being deposited with the United States Postal Service 'Express Mail Post Office To Addressee' service under 37 CFR 1 10 and is addressed to the Assistant Commissioner for Patents, Washington D.C 20231

By: [signature]
Name D. McGruder

BOX PCT
Assistant Commissioner for Patents
Washington, D.C. 20231

Sir:

We are transmitting herewith the attached:

- ☒ Transmittal sheet, in duplicate, containing Certificate under 37 CFR 1.10.
- ☒ Utility Patent Application: Spec. 8 pgs; 8 claims; Abstract 1 pgs.
  The fee has been calculated as shown below in the 'Claims as Filed' table.
- ☒ 3 sheets of formal drawings
- ☒ A signed Combined Declaration and Power of Attorney
- ☒ A check in the amount of $1070.00 to cover the Filing Fee
- ☒ Other: Preliminary Amendment, Transmittal Letter to the U.S. Designated/Elected Office, Information Disclosure Statement, Form 1449, copies of 11 references, IB/308
- ☒ Return postcard

CLAIMS AS FILED

Number of Claims Filed		In Excess of:		Number Extra		Rate		Fee
Basic Filing Fee								$1070.00
Total Claims								
8	–	20	=	0	x	22.00	=	$0.00
Independent Claims								
2	–	3	=	0	x	82.00	=	$0.00
MULTIPLE DEPENDENT CLAIM FEE								$0.00
TOTAL FILING FEE								$1070.00

Please charge any additional fees or credit overpayment to Deposit Account No. 13-2725. A duplicate of this sheet is enclosed.

MERCHANT, GOULD, SMITH, EDELL, WELTER & SCHMIDT
3100 Norwest Center, Minneapolis, MN 55402
(612) 332-5300

By: [signature]
Name: Michael B. Lasky
Reg. No.: 29,555
Initials: MBL/ssh

(PTO TRANSMITTAL – NEW FILING)

IN THE UNITED STATES PATENT AND TRADEMARK OFFICE

Applicant: PALLONEN, Jorma Docket No.: 10178.69USWO

Serial No.: TO BE ASSIGNED (Corresponding to PCT/FI97/00318)

Filed: 23 November 1998
International Filing Date: 26 May 1997

Title: METHOD FOR DETERMINING THE POSITION OF A MOBILE STATION

CERTIFICATE UNDER 37 CFR 1.10:
"Express Mail" mailing label number: EM402708478US
Date of Deposit: 23 November 1998

I hereby certify that this correspondence is being deposited with the United States Postal Service "Express Mail Post Office to Addressee" service under 37 CFR 1.10 on the date indicated above and is addressed to Assistant Commissioner for Patents, Washington, D.C. 20231.

By: _____
Name: D. Mc Gruder

PRELIMINARY AMENDMENT

Box PCT
Assistant Commissioner for Patents
Washington, D.C. 20231

Dear Sir:

In connection with the above-identified application filed herewith, please enter the following preliminary amendment:

IN THE ABSTRACT

Insert the attached Abstract page into the application as the last page thereof.

IN THE SPECIFICATION

Enclosed is a copy of Form PCT/IB/308 indicating communication of the international application to the Designated Offices. A courtesy copy of the present specification is enclosed herewith, however, but the World Intellectual Property Office (WIPO) copy should be relied upon if it is already in the U.S. Patent Office.

IN THE CLAIMS

Please enter the claims amended during prosecution of PCT/FI97/00318 and published in the International Preliminary Examination Report for that application as the claims for this application. A courtesy copy of those claims is included herewith but the World Intellectual Property Office (WIPO) copy should be relied upon if it is already in the U.S. Patent Office.

REMARKS

A new abstract page is supplied to conform to that appearing on the publication page of the WIPO application, but the new Abstract is typed on a separate page as required by U.S. practice.

The above preliminary amendment is made to enter the claims as amended during prosecution of the international phase of PCT/FI97/00318.

Applicant respectfully requests that the preliminary amendment described herein be entered into the record prior to calculation of the filing fee and prior to examination and consideration of the above-identified application.

If a telephone conference would be helpful in resolving any issues concerning this communication, please contact Applicant's primary attorney-of record, Michael B. Lasky.

Respectfully submitted,

MERCHANT, GOULD, SMITH, EDELL,
WELTER & SCHMIDT, P.A.
3100 Norwest Center
90 South 7th Street
Minneapolis, MN 55402
(612) 332-5300

Dated: 23 November 1998

By: _____
Michael B. Lasky
Reg. No. 29,555
MBL/ssh

PTO/PCT Rec'd 2? NOV 1998
PCT/FI97/00318

09/194297

METHOD FOR DETERMINING THE POSITION OF A MOBILE STATION

The invention relates to a method for determining the position of a mobile station located in the coverage area of a base station in a radio system, in which method the base station comprises equipment for receiving signals from the same mobile station simultaneously by at least two antenna beams directed in different directions, and in which method: the signal levels of the signals received by the different antenna beams are measured, the signal levels of the signals received from the same mobile station by the different antenna beams are compared, and the direction to the mobile station in relation to the base station is determined on the basis of the relations between the signal levels measured for the different antenna beams. The invention further relates to a base station of a radio system, which base station comprises antenna equipment for receiving signals from a certain mobile station simultaneously by at least two antenna beams directed in different directions, measuring equipment for measuring the signal levels of the signals received by the different antenna beams, calculation means which are responsive to the measuring equipment for determining the direction from the base station to the mobile station on the basis of the relations of the signal levels measured for the different antenna beams, and equipment for defining a timing advance for the mobile station, which is in radio connection with the base station, to compensate for a time lag caused by the distance between the mobile station and the base station.

By the notion antenna beams turned in different directions is here meant that the radio cell covered by the base station is divided into adjacent sectors from which signals related to the same logical channel (the same frequency channel and time slot) are received, and that a directional antenna or the equivalent is directed to each sector, by which antenna signals can be received from the sector in question. The antennas of the base station are, however, preferably directed so that they overlap at least partly in the border zones between them.

The invention relates to determining of the position of a mobile station in a cellular radio system, e.g. the GSM system (Groupe Spécial Mobile). Prior solutions are known where the position of the mobile station has, for example, been determined by checking from the home location register (HLR) of the mobile switching centre of the GSM-system in which radio cell the mobile

station is located at a certain moment. The most significant problem with this known solution is its inaccuracy. Since it can only be ascertained in which radio cell the mobile station is located in the known solutions mentioned before, the accuracy of determining the position, of course, directly depends on the size of the radio cell in question. The size of the radio cells again totally depends on the properties of the radio system, but in the GSM system, for example, the inaccuracy of determining the position according to the radio cell can typically be several kilometers.

However, in practice there has been a need for greater accuracy in determining the position of a mobile station. For example in connection with handover operations it would be necessary to determine the exact geographical position of the mobile station. At present handover is, for instance in the GSM system, based on the signal level and quality of the signals received, and by no means on the position of the mobile station. Thus temporary radio disturbances can lead to an unnecessary handover operation, i.e. the mobile station is transferred from one cell to another when the signal level or quality falls below a predetermined level, after which the handover operation is repeated but in the reverse direction, i.e. the mobile station is returned to the original cell when the disturbance is over

Another situation where it would be necessary to determine the exact position of the mobile station is when a stolen mobile station or for example a SIM Card (Subscriber Identity Module) is to be located. In known solutions, where the inaccuracy in locating the mobile station is several kilometers, it is practically impossible to determine the position of a stolen mobile station.

The object of the present invention is to solve the above mentioned problems and to achieve a more precise method for determining the position of a mobile station. This aim is achieved by the method of the invention, which is characterized in calculating the distance from the mobile station to the base station on the basis of a timing advance given to the mobile station by the base station and the propagation speed of the radio signals.

The invention also relates to a base station by which the method of the invention can be carried out. A base station according to the invention is characterized in that the calculation means comprise equipment for calculating the distance between the base station and the mobile station on the basis of the timing advance defined for the mobile station and the propagation speed of the radio signals.

The invention is based on the realization that the position of the mobile station can be determined with significantly greater accuracy than in known solutions when its signals are received by at least two antenna beams directed in different directions and when the audibility of the signals received by the respective beams from the mobile station is compared. In other words, the audibility of the signals transmitted by the mobile station is normally best for the beam that is directed straight towards the mobile station. Thus it can be determined within which beam the mobile station is located. When it is further known in which direction the beam in question is turned the direction to the mobile station can easily be determined. How near the centre or respectively the edges of the beam the mobile station is located can be determined by comparing the signal levels of the signals received by the beam in question to the signal levels of the signals received by "the principal beam". Thus the direction from the base station to the mobile station can be determined from the relation between the signal levels of the signals received by the respective beams. In addition to this the distance from the mobile station to the base station can, according to the invention, be calculated on the basis of a timing advance given to the mobile station by the base station and the propagation speed of the radio signals. In the GSM system, for example, there is already in use a so called timing advance TA given by the base station to the mobile station to inform it of how much in advance it should transmit its signals so that the signals will arrive at the right moment and in the proper time slot to the base station regardless of the distance between the mobile station and the base station. Thus, the distance between the base station and the mobile station can be determined on the basis of the timing advance when the propagation speed of the signals is known.

The most significant advantage with the solution of the invention is thus that the position of the mobile station, that is both its direction and distance from the base station, can be determined with significantly greater accuracy than previously, which among other things makes it possible to make handover decisions on the basis of the location of the mobile station, whereby unnecessary handover operations can be avoided, and for example to locate a stolen mobile station with greater accuracy than before.

So that temporary disturbances would not significantly disturb the determining of the position of the mobile station, in a preferred embodiment of the invention the mean value of the signal levels of the signals received by the

respective antennas from a certain mobile station is calculated for a certain time period, whereby the position of the mobile station is determined on the basis of the mean values of the calculated relations.

The preferred embodiments of the method and base station of the invention are revealed in the attached dependent claims 2 - 4 and 6 - 8.

In the following the invention will be described in more detail in a few preferred embodiments by mean of the attached drawings, in which

Figure 1 shows a flowchart of a first preferred embodiment of the method of the invention,

Figure 2 illustrates a first preferred embodiment of a base station of the invention,

Figure 3 shows an enlargement of the receiving beams of the base station in Figure 2, and

Figure 4 shows a block diagram of the base station in Figure 2.

Figure 1 shows a block diagram of a first preferred embodiment of the method of the invention. The block diagram in Figure 1 can, for example, be applied in a base station of the GSM system to determine the position of a mobile station.

In block A signals are received from a mobile station MS by several antenna beams directed in different directions. The antenna beams used are preferably relatively narrow beams that are directed so that they at least partly overlap (compare with Figure 2).

In block B the received signal strength indication RSSI of the received signal is measured for the signals received by the respective beams.

In block C a mean value is calculated for the RSSI values measured within a certain time span for each beam. By calculating the mean value for the RSSI values it can be avoided that temporary disturbances influence the locating of the mobile station. For example in the GSM system the time span in question can be chosen so that the mean value is calculated for a few bursts received from the mobile station.

In block D a first beam is chosen which has the highest RSSI mean value (=RSSI1). In addition to this at least one of the adjacent beams is chosen as a second beam, whereby preferably the beam with the higher RSSI mean value (=RSSI2) is chosen.

In block E the RSSI values for the different beams are compared by calculating the ratio of the RSSI mean values RSSI1/ RSSI2 for the chosen

beams.

In block F it is checked if the RSSI ratio for the beams is greater than the predetermined reference value K. The reference value is chosen so that it is essentially greater than 1. If the RSSI ratio exceeds the reference value that denotes that the audibility of the mobile station is much better by the first chosen beam than by the second chosen beam, which means that the mobile station is located in the direction of the centre of the first beam. Hereby a transfer is made to block G, where the direction of the first chosen beam is specified, which is the direction where the mobile station is located.

In block H it is checked if the RSSI ratio is nearly 1. If that is the case it denotes that the audibility of the mobile station is almost equally good via both the chosen beams. This again means that the mobile station is located in the border zone between the two beams. Hereby a transfer is made to block I, where the direction is specified where the border zone between the beams (and the mobile station) is located.

Provided that the RSSI ratio of the beams is not greater than the reference value K, neither the RSSI ratio nearly 1, a transfer is made to block J. Thus it is ascertained that the audibility of the mobile station is somewhat better via the first chosen beam than via the second chosen beam, which means that the mobile station is located between the centre of the first chosen beam and the border zone between the chosen beams. If it is necessary to determine the direction to the mobile station more accurately than that, the direction in question can be determined by the RSSI ratio of the beams. That requires measurements made in advance so that a precise picture can be had of how the RSSI ratio between the beams changes when the mobile station moves from the border zone between the beams to the centre of the first beam.

By following the flowchart in Figure 1 only the direction from the base station to the mobile station can be determined. In addition to this it can be necessary also to determine the distance from the base station to the mobile station. According to the invention the distance in question can be calculated on the basis of the timing advance given to the mobile station by the base station, that is

distance = timing advance * propagation speed of the radio signals

How accurately the position of the mobile station can be determined in relation to the base station of course depends on the width of the antenna beams used and how accurately the base station calculates the timing advance for the mobile station. For example in the GSM system the position of the mobile station can be determined as described above with an accuracy of typically about 0,5 x 0,5 km, when the width of the antenna beams is about 30°.

Figure 2 illustrates a first embodiment of a base station of the invention. The base station BTS1 in Figure 2 can, for example, be a base station in the GSM system, which base station comprises equipment for receiving signals transmitted by the mobile station MS from the radio cell in the figure simultaneously by four receiving beams 1 - 4. In Figure 2 the boundaries of the radio cell have been illustrated by a dash line R.

The mobile station MS of Figure 2 is located in the border zone between beams 1 and 2, whereby its audibility is almost as good by beam 1 as by beam 2. That is the RSSI ratio for beams 1 and 2 calculated by the base station BTS1 is nearly 1.

Figure 3 shows an enlargement of the receiving beams 1 and 2 of the base station in Figure 3. It is assumed that the base station BTS1 has received the signals with greater signal strength via beam 1. In that case the mobile station that has transmitted the signals in question is located in the area covered by beam 1. If the mobile station is located in the centre of beam 1, that is in the striped area A1 in Figure 3, the base station will recognize that as the calculated RSSI values for beam 1 are considerably greater than those for beam 2. That is the RSSI ratio is essentially greater than 1.

If the mobile station is located in the border zone A2 between the beams the base station will recognize that as the RSSI values calculated for beams 1 and 2 are essentially as great, that is the RSSI ratio is nearly 1.

If the mobile station is located between the centre A1 of beam 1 and the border area between beams 1 and 2, that is in the area A3, the base station will recognize that as the RSSI values measured for beam 1 are somewhat greater than the RSSI values measured for beam 2.

Figure 4 shows a block diagram of the base station in Figure 2. The signals related to the same logical channel that are received by the base station BTS1 by the antenna beams 1 - 4 are fed through band-pass filters 7 and amplifiers 6 to the RSSI receiver 8 of the base station. In Figure 4 the RSSI

receiver 8 is shown in connection with the base station, but to facilitate cabling the RSSI receiver can also be arranged in connection with an antenna element in the antenna mast of the base station.

In the example in Figure 4 there are 4 inputs and one output. The RSSI receiver chooses one of the signals fed into its inputs for further transmission via its output to the receiver RX of the base station. In the base station in Figure 4 the RSSI receiver 8 chooses a signal for further transmission by measuring the signal level RSSI for the signals received by each antenna beam 1 - 4 and by choosing the beam for which the greatest RSSI value has been measured. Alternately the RSSI receiver can choose the beam also in some other way, by also including a value representing signal quality like the bit error ratio BER in addition to the RSSI value. A solution like that will, however, complicate the construction of the RSSI receiver.

If such a receiver is used that can manage diversity reception, the RSSI receiver can have two outputs, whereupon the RSSI receiver chooses the two best antenna beams for use and transmits the signals received by these further to the actual receiver of the base station. With an arrangement like this an improvement of about 3 dB can be achieved in the reception of signals from a mobile station in the border zone between the sectors.

According to the invention the RSSI receiver 8 feeds the RSSI values measured for the respective beams to the calculator 9. The calculator 9 can for example be a processor and a computer program added to the base station for locating the mobile station.

The calculator 9 calculates the mean value of the received signals for each antenna beam on the basis of the measuring results. Since the base station in Figure 4 is a base station of the GSM system, where the frequency channels have been divided into time slots according to the TDMA principle, the calculator 9 first calculates a mean value for each antenna beam separately for each logical channel. After this the calculator specifies the direction from the base station to the mobile station as shown in the flowchart in Figure 1.

A signal denoting the timing advance TA given to the mobile station by the base station is according to the invention also fed to the calculator 9. On the basis of this signal the calculator calculates the distance to the mobile station as described in connection with the flowchart in Figure 1.

The signal POS fed from the output of the calculator thus denotes

the position of the mobile station in relation to the base station (direction + distance). For instance handover operations can be timed better on the basis of this information, since they are then based on information about the position of the mobile station. Additionally the information about the position of the mobile station can be transmitted further via the base station controller and the mobile switching centre to the network management centre, whereupon the operator can determine the position of the mobile station with even greater accuracy from the network management centre.

It is to be understood that the above description and the related drawings are only intended to illustrate the present invention. Thus the invention can also be applied in other cellular radio systems than the GSM system. To those skilled in the art various other modifications and variations of the invention will be apparent within the scope and spirit of the present invention disclosed in the attached claims.

CLAIMS

(Amended on August 4, 1998)

1. A method for determining the position of a mobile station located in the coverage area of a base station in a radio system and for using said information, in which method the base station comprises equipment for receiving signals from the same mobile station simultaneously by at least two antenna beams (A) directed in different directions, and in which method:

the signal levels (B) of the signals received by the different antenna beams are measured,

the signal levels of the signals received from the same mobile station by the different antenna beams are compared (C, D, E),

the direction to the mobile station in relation to the base station is determined on the basis of the relations between the signal levels (F, G, H, I, J) measured for the different antenna beams, and

the distance from the mobile station to the base station is calculated on the basis of a timing advance (TA), given to the mobile station by the base station and the propagation speed of the radio signals, **characterized** in that

said distance and said direction is used for making a handover decision on the basis of the location of the mobile station.

2. A method according to claim 1, **characterized** in calculating a mean value for the measuring results during a determined time period (C) and determining the direction to the mobile station on the basis of the relations between the calculated mean values.

3. A method according to claim 1, **characterized** in choosing a beam by which signals with the strongest signal level have been received and at least one of the adjacent beams (D), comparing the measured signal levels for the antenna beams in question (E), and determining the direction to the mobile station on the basis of the relation between the signal levels for the chosen antenna beams.

4. A method according to claim 1, **characterized** in determining that the mobile station is located

- in the centre (A1) of the first chosen beam, if the signal level (RSSI1) of the signals received by the beam in question (1) is essentially

higher than the signal level (RSSI2) of the signals received by the other chosen antenna beam (2),

- in the border area (A2) between the antenna beams, if the signal level (RSSI1, RSSI2) of the signals received by the chosen antenna beams (1, 2) is substantially the same, and

- between (A3) the centre (A1) of the first chosen antenna beam (1) and the border zone (A2) of the beams (1, 2), if the signal level (RSSI1) of the signals received by the first antenna beam (1) is somewhat higher than the signal level (RSSI2) of the signals received by the other antenna beam.

5. Base station (BTS1) of a radio system, which base station comprises

antenna equipment (1 - 4, 6, 7) for receiving signals from a certain mobile station simultaneously by at least two antenna beams (1 - 4) directed in different directions,

measuring equipment (8) for measuring the signal levels of the signals received by the different antenna beams,

equipment for defining a timing advance (TA) for the mobile station (MS) which is in radio connection with the base station to compensate for a time lag caused by the distance between the mobile station and the base station, and

calculation means (9) which are responsive to the measuring equipment (8) for determining the direction from the base station (BTS1) to the mobile station (MS) on the basis of the relations of the signal levels measured for the different antenna beams (1 - 4) and which calculation means (9) comprise equipment for calculating the distance between the base station (BTS1) and the mobile station (MS) on the basis of the timing advance (TA) defined for the mobile station and the propagation speed of the radio signals, **characterized** in that

said calculation means are adapted to transmit said direction and said distance further in the system in order to be used for making handover decisions.

6. Base station according to claim 5, **characterized** in that the calculation means (9) are arranged for calculating for each beam (1 - 4) the mean value of the signal levels of the signals received from the mobile station (MS) by the respective antenna beams, whereby the calculation means (9) are arranged to determine the direction from the base station (BTS1) to the

mobile station (MS) on the basis of relations between the calculated mean values.

7. Base station according to claim 5, **characterized** in that the calculation means (9) include means for choosing the antenna beam (1) with the strongest signal level and at least one adjacent beam (2), whereby the calculating means (9) are arranged for determining the direction from the base station (BTS1) to the mobile station (MS) on the basis of the relations of the signal levels (RSSI1, RSSI2) of the signals received via the chosen antenna beams (1, 2).

8. Base station according to claim 5, **characterized** in that said base station is a base station (BTS1) of a cellular radio system divided into logical traffic channels in accordance with a TDMA principle.

ABSTRACT

The present invention relates to a base station of a cellular radio system, which base station comprises antenna equipment for receiving signals from a certain mobile station simultaneously by at least two antenna beams directed in different directions, and measuring equipment for measuring the signal levels of the signals received by the respective antenna beans. For determining the position of the mobile station with greater accuracy the base station is provided with calculating means which are responsive to the measuring equipment to determine the direction from the base station to the mobile station by calculating the relations between the signal levels of the signals for the respective beams.

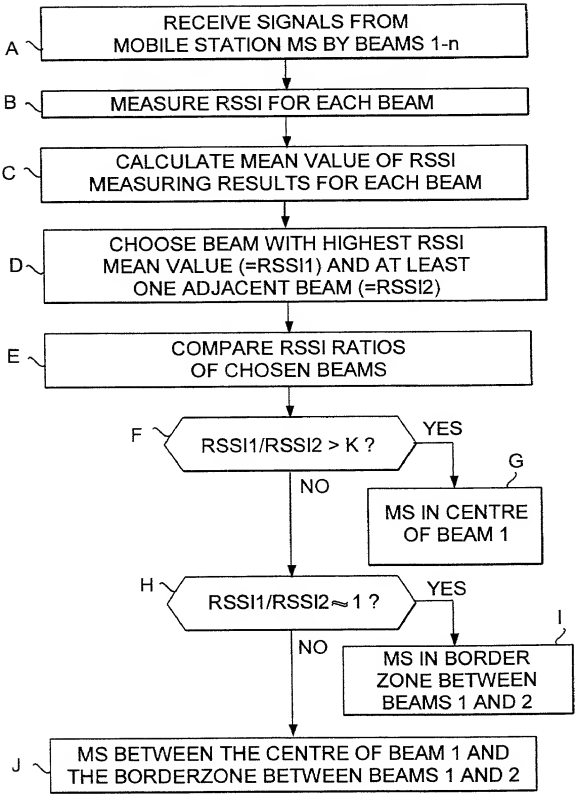
A
RECEIVE SIGNALS FROM MOBILE STATION MS BY BEAMS 1-n
B
MEASURE RSSI FOR EACH BEAM
C
CALCULATE MEAN VALUE OF RSSI MEASURING RESULTS FOR EACH BEAM
D
CHOOSE BEAM WITH HIGHEST RSSI MEAN VALUE (=RSSI1) AND AT LEAST ONE ADJACENT BEAM (=RSSI2)
E
COMPARE RSSI RATIOS OF CHOSEN BEAMS
F
RSSI1/RSSI2 > K ?
YES
G
MS IN CENTRE OF BEAM 1
NO
H
RSSI1/RSSI2≈1 ?
YES
I
MS IN BORDER ZONE BETWEEN BEAMS 1 AND 2
NO
J
MS BETWEEN THE CENTRE OF BEAM 1 AND THE BORDERZONE BETWEEN BEAMS 1 AND 2

FIG. 1

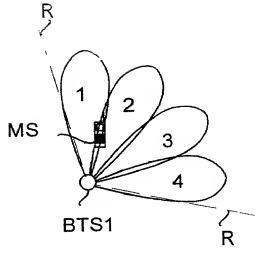

FIG. 2

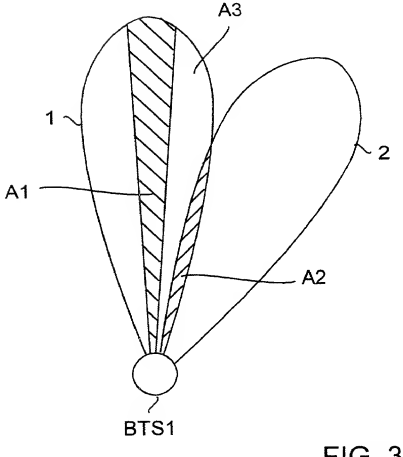

FIG. 3

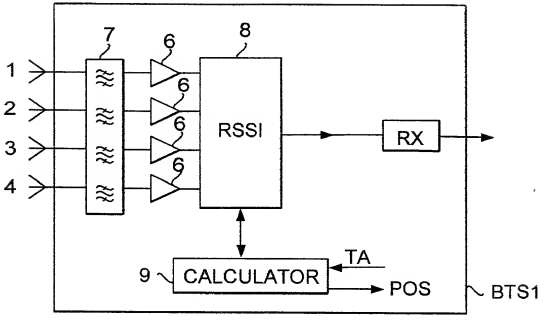

FIG. 4

See Chart - PCT and Design Applications

MERCHANT & GOULD

United States Patent Application

▼ INSTRUCTIONS

COMBINED DECLARATION AND POWER OF ATTORNEY

As a below named inventor I hereby declare that: my residence, post office address and citizenship are as stated below next to my name; that

I verily believe I am the original, first and sole inventor (if only one name is listed below) or a joint inventor (if plural inventors are named below) of the subject matter which is claimed and for which a patent is sought on the invention entitled:

Insert TITLE of invention: Method for determining the position of a mobile station

Check a or b

The specification of which

a. ☐ is attached hereto

b. ☐ was filled on _____

If "b" checked, complete

as application serial no. _____

and was amended on _____ (if applicable)

If PCT Application

(in the case of PCT-filed application)

Insert Int. application number & filing date

described and claimed in international no. PCT/FI97/00318 filed 26 May 1997

and as amended on 4 August 1998 (if any), which I have reviewed and for which I solicit a United States patent.

I hereby state that I have reviewed and understand the contents of the above identified specification, including the claims, as amended by any amendment referred to above.

I acknowledge the duty to disclose information which is material to the examination of this application in accordance with Title 37, Code of Federal Regulations, § 1.56(a). (Reprinted on back side).

I hereby claim foreign priority benefits under Title 35, United States Code, § 119/365 of any foreign application(s) for patent of inventor's certificate listed below and have also identified below any foreign application for patent or inventor's certificate having a filing date before that of the application on the basis of which priority is claimed:

Prior applications Check a or b

a. ☐ no such applications have been filed.

b. ☒ such applications have been filed as follows:

If "b" checked, complete

FOREIGN APPLICATION(S), IF ANY, CLAIMING PRIORITY UNDER 35 USC §119			
COUNTRY	APPLICATION NUMBER	DATE OF FILING (day, month, year)	DATE OF ISSUE (day, month, year)
Finland	962215	27 May 1996	
ALL FOREIGN APPLICATIONS, IF ANY, FILED BEFORE THE PRIORITY APPLICATION(S)			
COUNTRY	APPLICATION NUMBER	DATE OF FILING (day, month, year)	DATE OF ISSUE (day, month, year)

I hereby claim the benefit under Title 35, United States Code, § 120/365 of any United States and PCT international application(s) listed below and, insofar as the subject matter of each of the claims of this application is not disclosed in the prior United States application in the manner provided by the first paragraph of Title 35, United States Code, § 112, I acknowledge the duty to disclose material information as defined in Title 37, Code of Federal Regulations, § 1.56(a) which occurred between the filing date of the prior application and the national or PCT international filing date of this application.

Revised 11/01/92

For Continuation-in-Part (CIP) Applications, complete

U.S. APPLICATION NUMBER	DATE OF FILING (day, month, year)	STATUS (patented, pending, abandoned)

I hereby appoint the following attorney(s) and/or patent agent(s) to prosecute this application and to transact all business in the Patent and Trademark Office connected herewith:

Bartingale, Kari H.	Reg. No. 35,183	Hassing, Thomas A.	Reg. No. 36,159	Schumann, Michael D.	Reg. No. 30,422
Batzli, Brian H.	Reg. No. 32,960	Hillson, Randall A.	Reg. No. 31,838	Schwappach, Karl G.	Reg. No. 35,786
Beard, John L.	Reg. No. 27,612	Kluth, Daniel J.	Reg. No. 32,146	Schwegman, Micheal L.	Reg. No. 25,816
Beck, Robert C.	Reg. No. 28,184	Kowalchyk, Alan W.	Reg. No. 31,535	Sebald, Gregory A.	Reg. No. 33,280
Bogucki, Raymond A.	Reg. No. 17,426	Kowalchyk, Katherine M.	Reg. No. 36,848	Smith, Phillip H.	Reg. No. 20,676
Brennan, Thomas F.	Reg. No. 35,075	Lasky, Michael B.	Reg. No. 29,555	Sorenson, Andrew D.	Reg. No. 33,606
Bruess, Steven C.	Reg. No. 34,130	Lundberg, Steven W.	Reg. No. 30,568	Strawbridge, Douglas A.	Reg. No. 28,576
Byrne, Linda M.	Reg. No. 32,404	Lynch, David W.	Reg. No. 36,204	Stroebhoff, Kristina M.	Reg. No. 34,259
Carlson, Alan G.	Reg. No. 25,959	Mau, Michael L.	Reg. No. 30,087	Sumner, John P.	Reg. No. 29,114
Caspers, Philip P.	Reg. No. 33,227	McDonald, Daniel W.	Reg. No. 32,044	Sumners, John S.	Reg. No. 24,216
Clifford, John A.	Reg. No. 30,247	McDonald, Wendy M.	Reg. No. 32,427	Tellekson, David K.	Reg. No. 32,314
Conrad, Timothy R.	Reg. No. 30,164	Michel, Michelle M.	Reg. No. 33,968	Underhill, Albert L.	Reg. No. 27,403
DiPietro, Mark J.	Reg. No. 28,707	Moy, R. Carl	Reg. No. 30,725	Vandenburgh, J. Derek	Reg. No. 32,179
Edell, Robert T.	Reg. No. 20,187	Mueting, Ann M.	Reg. No. 33,977	Viezbe, Lance L.	Reg. No. 36,208
Freed, Robert C.	Reg. No. 32,569	Nelson, Albin J.	Reg. No. 28,650	Welter, Paul A.	Reg. No. 20,890
Gaither, Peter J.	Reg. No. 36,517	Raasch, Kevin W.	Reg. No. 35,651	Williams, Douglas J.	Reg. No. 27,054
Gates, George H.	Reg. No. 33,500	Reiland, Earl D.	Reg. No. 25,767	Woessner, Warren D.	Reg. No. 30,440
Golla, Charles E.	Reg. No. 26,896	Reggans, Jesse D.	Reg. No. 36,477	Wood, Gregory B.	Reg. No. 28,133
Gould, John D.	Reg. No. 18,223	Rothfus, Joel A.	Reg. No. 33,277		
Greener, John J.	Reg. No. 33,113	Schmidt, Cecil C.	Reg. No. 20,566		
Hamre, Curtis B.	Reg. No. 29,165	Schuman, Mark D.	Reg. No. 31,197		

I hereby authorize them to act and rely on instructions from and communicate directly with the person/assignee/attorney/firm/organization/who/which first sends/sent this case to them and by whom/which I hereby declare that I have consented after full disclosure to be represented unless/until I instruct Merchant, Gould to the contrary.

Please direct all correspondence in this case to Merchant, Gould, Smith, Edell, Welter & Schmidt at the address indicated below (or if no address is specified, the firm address):

☐ 3100 Norwest Center, Minneapolis, MN 55402-4131 Telephone No. (612) 332-5300

☐ 1000 Norwest Center, St. Paul, MN 55101-2701 Telephone No. (612) 298-1055

☐ Suite 1700, 11100 Santa Monica Boulevard, Los Angeles, CA 90025-3302 Telephone No. (310) 445-1140

I hereby declare that all statements made herein of my own knowledge are true and that all statements made on information and belief are believed to be true; and further that these statements were made with the knowledge that willful false statements and the like so made are punishable by fine or imprisonment, or both, under Section 1001 of Title 18 of the United States Code and that such willful false statements may jeopardize the validity of the application or any patent issued thereon.

Insert FULL name(s) AND address(es) of actual inventor(s)

1-00

201	FULL NAME OF INVENTOR	FAMILY NAME: PALLONEN	FIRST GIVEN NAME: Jorma	SECOND GIVEN NAME
	RESIDENCE & CITIZENSHIP	CITY: Helsinki	STATE OR FOREIGN COUNTRY: Finland	COUNTRY OF CITIZENSHIP: Finland
	POST OFFICE ADDRESS	POST OFFICE ADDRESS: Pitkäsillanranta 7-9 E 128	CITY: FIN-00530	STATE & ZIP CODE/COUNTRY: Helsinki, Finland
202	FULL NAME OF INVENTOR	FAMILY NAME	FIRST GIVEN NAME	SECOND GIVEN NAME
	RESIDENCE & CITIZENSHIP	CITY	STATE OR FOREIGN COUNTRY	COUNTRY OF CITIZENSHIP
	POST OFFICE ADDRESS	POST OFFICE ADDRESS	CITY	STATE & ZIP CODE/COUNTRY
203	FULL NAME OF INVENTOR	FAMILY NAME	FIRST GIVEN NAME	SECOND GIVEN NAME
	RESIDENCE & CITIZENSHIP	CITY	STATE OR FOREIGN COUNTRY	COUNTRY OF CITIZENSHIP
	POST OFFICE ADDRESS	POST OFFICE ADDRESS	CITY	STATE & ZIP CODE/COUNTRY

FIX

Each inventor must sign & date

Note: No legalization or other witness required

SIGNATURE OF INVENTOR 201	SIGNATURE OF INVENTOR 202	SIGNATURE OF INVENTOR 203
[signature]		
DATE: 10.11.1998	DATE	DATE

For Additional Inventors:

☐ Check box and attach sheet with same information, including date and signature.

Revised 11/1/95